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उच्च वोल्टेज के स्विच

भाग 1 1 कि॰ वो॰ से ऊपर की तथा 52 कि॰ वो॰ से कम की रेटित वोल्टेज के स्विच

(पहला पुनरीक्षण)

Indian Standard

HIGH VOLTAGE SWITCHES

PART 1 SWITCHES FOR RATED VOLTAGES ABOVE 1 kV AND LESS THAN 52 kV

(First Revision)

ICS 29.130.10

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

September 2002 **Price Group 14**

High Voltage Switchgear and Controlgear Sectional Committee, ET 08

NATIONAL FOREWORD

This Indian Standard (Part 1) (First Revision) which is identical with IEC 60265-1(1998) 'High-voltage switches — Part 1: Switches for rated voltages above 1 kV and less than 52 kV' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the High Voltage Switchgear and Controlgear Sectional Committee and approval of the Electrotechnical Division Council.

The text of the IEC Standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'; and

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

Corrigendum to the above International Standard has been printed at the end.

CROSS REFERENCES

In this adopted standard, references appear to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60050(441) (1984) International Electrotechnical Vocabulary (IEV) — Chapter 441: Switchgear, controlgear and fuses	IS 1885 (Part 17) : 1979 Electrotechnical vocabulary: Part 17 Swithgear and controlgear (*first revision*)	Technically equivalent
IEC 60056 (1987) High voltage alternating-current circuit-breakers	IS 13118 : 1991 General requirements for circuit breakers for voltages above 1 000 V (Superseding all Parts and Sections of IS 2516)	Identical
IEC 60059 (1938) IEC standard current ratings	IS 11955:1987 Preferred current ratings	Technically equivalent
IEC 60071-1 (1993) Insulation coordination — Part 1: Definitions, principles and rules	a) IS 2165 (Part 1) : 1977 Insulation coordination: Part 1 Phase to earth insulation coordination, principles and rules (*second revision*)	do

(*Continued on third cover*)

Indian Standard

HIGH VOLTAGE SWITCHES

PART 1 SWITCHES FOR RATED VOLTAGES ABOVE 1 kV AND LESS THAN 52 kV

(First Revision)

1 General

1.1 Scope

This part of IEC 60265 is applicable to three-phase, alternating current switches and switch-disconnectors having making and breaking current ratings, for indoor and outdoor installations, for rated voltages above 1 kV and less than 52 kV and for rated frequencies from 16 $^2/_3$ Hz up to and including 60 Hz.

This standard is also applicable to the operating devices of these switches and to their auxiliary equipment.

Switch-disconnectors are also covered by IEC 60129.

General principles and provisions of this standard may also be applicable to single pole switches intended for application in single-phase systems. The requirements for dielectric tests and making and breaking tests should be in accordance with the requirements of the specific application.

NOTE 1 – Except where special clarification is required, the term "switch" is used to refer to all kinds of switches and switch-disconnectors within the scope of this standard.

NOTE 2 – Earthing switches are not covered by this standard. Earthing switches forming an integral part of a switch are covered by IEC 60129.

NOTE 3 – This standard is not applicable to switching devices attached as an accessory to a high-voltage fuse assembly or its mounting and operated by opening and closing the fuse assembly.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60265. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 60265 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(441):1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*

IEC 60056:1987, *High-voltage alternating-current circuit-breakers*

IEC 60059:1938, *IEC standard current ratings*

IEC 60071-1:1993, *Insulation coordination – Part 1: Definitions, principles and rules*

IEC 60129:1984, *Alternating current disconnectors and earthing switches*

IEC 60420:1990, *High-voltage alternating current switch-fuse combinations*

IEC 60694:1996, *Common specifications for high-voltage switchgear and controlgear standards*

IEC 61233:1994, *High-voltage alternating current circuit-breakers – Inductive load switching*

1.101 General requirements

The main purpose of this standard is to establish requirements for general purpose switches used in distribution systems.

General purpose switches shall comply with the following service applications:

- carrying normal current continuously;
- switching of mainly active loads;
- switching of distribution line closed-loop circuits;
- switching of no-load transformers;
- switching of the charging current of unloaded cables and overhead lines;
- carrying short-circuit currents for a specified time;
- making short-circuit currents.

General purpose switches intended for use in isolated neutral systems or in systems earthed by a high impedance shall be capable of switching under earth fault conditions.

A further object of this standard is to establish requirements for limited purpose and special purpose switches used in distribution systems.

Limited purpose switches shall have a rated normal current, a rated short-time withstand current, and one or more, but not all, of the switching capabilities of a general purpose switch.

Special purpose switches shall have a rated normal current, a rated short-time withstand current, a rated short-circuit making current and, in addition, shall be suitable for one or more of the following applications:

- switching single capacitor banks;
- switching back-to-back capacitor banks;
- switching of closed-loop circuits consisting of large power transformers in parallel;
- switching of motors under steady-state and stalled conditions.

It is assumed that opening and closing operations are performed according to the manufacturer's instructions. A making operation may immediately follow a breaking operation but a breaking operation shall not immediately follow a making operation since the current to be broken may then exceed the rated breaking current of the switch.

2 Normal and special service conditions

IEC 60694 is applicable.

3 Definitions

For the purpose of this part of IEC 60265, the definitions of IEC 60050(441) and IEC 60694 apply. Some of them are recalled hereunder for easier use.

The definitions given below are also applicable. They are classified in accordance with IEC 60050(441). The definitions of IEC 60050(441) are not repeated but reference is made to their specific subclause number. The additional definitions are classified so as to be aligned with the classification used in International Electrotechnical Vocabulary IEC 60050(441).

3.1 General terms

No particular definitions.

3.2 Assemblies

No particular definitions.

3.3 Parts of assemblies

No particular definitions.

3.4 Switching devices

3.4.101
switch
switching device capable of making, carrying and breaking currents under normal circuit conditions, which may include specified operating overload conditions and also carrying for a specified time currents under specified abnormal circuit conditions, such as those of a short-circuit [IEV 441-14-10, modified]

3.4.102
switch-disconnector
[IEV 441-14-12]

3.4.103
general purpose switch
switch capable of performing, with currents up to its rated breaking currents, all making and breaking operations which may normally occur in distribution systems. The switch shall also be capable of carrying and making short-circuit currents.

3.4.103.1
class E1 general purpose switch
general purpose switch suitable for applications in normally continuously fed parts of distribution system and where infrequent switching operations are performed

3.4.103.2
class E2 general purpose switch
general purpose switch designed so as not to require inspection or maintenance of the interrupting parts of the main circuit and only minimal maintenance of its other parts during its expected operating life

NOTE – Minimal maintenance may include lubrication, replenishment of gas, and cleaning of external surfaces, where applicable.

3.4.103.3
class E3 general purpose switch
general purpose switch having the capability of frequent switching of higher currents and a higher frequency of making on short-circuits

3.4.103.4
class M1 general purpose switch
general purpose switch suitable for applications requiring a mechanical endurance of 1 000 operations

3.4.103.5
class M2 general purpose switch
general purpose switch suitable for special service applications and for frequent operation having an extended mechanical endurance of 5 000 operations

NOTE – Class M2 switches may also be suitable for limited purpose and special purpose switch classifications.

3.4.104
limited purpose switch
switch which has a rated normal current, a rated short-time withstand current, and one or more switching capabilities of a general purpose switch

3.4.105
special purpose switch
switch which has a rated normal current, a rated short-time withstand current, a rated short-circuit making current, and is capable of performing specific service duties for special applications

NOTE 1 – Examples of such special requirements are capacitor bank switching, motor switching and parallel power-transformer switching.

NOTE 2 – In certain applications, other devices are utilized which will make short circuits or prevent the switch from making on a short circuit. In these applications, a short-circuit making capability is not required. The user should specify accordingly.

3.4.105.1
single capacitor bank switch
special purpose switch intended for switching of a single capacitor bank with charging currents up to its rated single capacitor bank breaking current

3.4.105.2
back-to-back capacitor bank switch
special purpose switch intended for breaking capacitor bank charging currents with one or more capacitor banks connected to the supply side of the switch up to its rated back-to-back capacitor bank breaking current. The switch shall be capable of making the associated inrush current up to its rated capacitor bank inrush making current.

3.4.105.3
motor switch
special purpose switch intended for switching of motors under steady-state and stalled conditions

3.4.105.4
parallel power transformer closed-loop switch
special purpose switch intended for switching a closed-loop circuit consisting of large power transformers in parallel. The switch is typically applied as a medium voltage tie switch on the transformer secondary circuit such that the breaking current is high and the transient recovery voltage (TRV) conditions are severe.

3.5 Parts of switching devices

No particular definitions.

3.6 Operation

No particular definitions.

3.7 Characteristic quantities

3.7.101
breaking capacity
[IEV 441-17-08]

3.7.102
mainly active load-breaking capacity
breaking capacity when opening a mainly active load circuit, the power factor of which is at least 0,75, in which the load can be represented by resistors and reactors in parallel

3.7.103
no-load transformer breaking capacity
breaking capacity when opening a transformer circuit under no-load conditions

3.7.104
closed-loop breaking capacity
breaking capacity when opening a closed-loop distribution line circuit, or a power transformer in parallel with one or more power transformers, i.e., a circuit in which both sides of the switch remain energized after breaking, and in which the voltage appearing across the terminals is substantially less than the system voltage

3.7.105
cable-charging breaking capacity
breaking capacity when opening a cable circuit under no-load conditions

3.7.106
line-charging breaking capacity
breaking capacity when opening an overhead line circuit under no-load conditions

3.7.107
single capacitor bank breaking capacity
breaking capacity when opening a single capacitor bank circuit connected to a supply that does not include another capacitor bank adjacent to the bank being switched

3.7.108
back-to-back capacitor bank breaking capacity
breaking capacity when opening a capacitor bank circuit connected to a supply that includes one or more capacitor banks adjacent to the bank being switched

3.7.109
back-to-back capacitor bank inrush making current
high-frequency and high-magnitude current occurring when closing a capacitor bank circuit onto a supply including one or more capacitor banks adjacent to the bank being switched

NOTE – The frequency and magnitude of the inrush current depend upon the values of capacitance and inductance between the capacitor banks.

3.7.110
motor breaking capacity
breaking capacity when opening a motor under steady-state and stalled conditions

3.7.111
earth fault breaking capacity
breaking capacity in the faulty phase of an isolated neutral or resonant earthed system when clearing an earth fault on an unloaded cable or overhead line on the load side of the switch

3.7.112
cable- and line-charging breaking capacity under earth fault conditions
breaking capacity in the sound phases of an isolated neutral or resonant earthed system when switching off an unloaded cable or overhead line, with an earth fault on the supply side of the switch

3.7.113
breaking current
[IEV 441-17-07]

3.7.114
(peak) making current
peak value of the first major loop of the current in a pole of a switch during the transient period following the initiation of current during a making operation

NOTE 1 – Peak value may differ from one pole to another and from one operation to another as it depends on the instant of current initiation relative to the wave of the applied voltage.

NOTE 2 – Where, for a three-phase circuit, a single value of (peak) making current is referred to, it is, unless otherwise stated, the highest value in any phase.

3.7.115
short-circuit making capacity
[IEV 441-17-10]

3.8 Index of definitions

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4 Ratings

Clause 4 of IEC 60694 is applicable with the additions and exceptions indicated below.

4.1 Rated voltage (U_r)

Subclause 4.1 of IEC 60694 is applicable.

4.2 Rated insulation level

Subclause 4.2 of IEC 60694 is applicable.

4.3 Rated frequency (f_r)

Subclause 4.3 of IEC 60694 is applicable.

4.4 Rated normal current (I_r) and temperature rise

Subclause 4.4 of IEC 60694 is applicable.

4.5 Rated short-time withstand current (I_k)

Subclause 4.5 of IEC 60694 is applicable with the following addition.

The rated short-time withstand current of an earthing switch forming an integral part of a switch shall be equal to the rated short-time withstand current of the switch, unless otherwise agreed to between the manufacturer and the user.

4.6 Rated peak withstand current (I_p)

Subclause 4.6 of IEC 60694 is applicable.

4.7 Rated duration of short-circuit (t_k)

Subclause 4.7 of IEC 60694 is applicable.

4.8 Rated supply voltage of closing and opening devices and of auxiliary and control circuits (U_a)

Subclause 4.8 of IEC 60694 is applicable.

4.9 Rated supply frequency of closing and opening devices and of auxiliary circuits

Subclause 4.9 of IEC 60694 is applicable.

4.10 Rated pressure of compressed gas supply for operation and/or interruption

Subclause 4.10 of IEC 60694 is applicable.

4.101 Rated mainly active load-breaking current (I_1)

The rated mainly active load-breaking current is the maximum mainly active load current that the switch shall be capable of breaking at its rated voltage.

4.102 Rated closed-loop breaking current (I_{2a} and I_{2b})

The rated closed-loop breaking current is the maximum closed-loop current the switch shall be capable of breaking. Separate ratings for distribution line loop breaking current and parallel power transformer breaking current may be assigned.

4.103 Rated no-load transformer breaking current (I_3)

The rated no-load transformer breaking current is the maximum no-load transformer current the switch shall be capable of breaking at its rated voltage.

4.104 Rated cable-charging breaking current (I_{4a})

The rated cable-charging breaking current is the maximum cable-charging current that the switch shall be capable of breaking at its rated voltage.

4.105 Rated line-charging breaking current (I_{4b})

The rated line-charging breaking current is the maximum line-charging current that the switch shall be capable of breaking at its rated voltage.

4.106 Rated single capacitor bank breaking current for special purpose switches (I_{4c})

The rated single capacitor bank breaking current is the maximum capacitor bank current that a special purpose switch shall be capable of breaking at its rated voltage with no capacitor bank connected to the supply side of the switch adjacent to the bank being switched.

4.107 Rated back-to-back capacitor bank breaking current for special purpose switches (I_{4d})

The rated back-to-back capacitor bank breaking current is the maximum capacitor bank current that a special purpose switch shall be capable of breaking at its rated voltage with one or more capacitor banks connected on the supply side of the switch adjacent to the bank being switched.

4.108 Rated back-to-back capacitor bank inrush making current for special purpose switches (I_{in})

The rated back-to-back capacitor bank inrush making current is the peak value of the current that a special purpose switch shall be capable of making at its rated voltage and with a frequency of the inrush current appropriate to the service conditions.

The assignment of a rated back-to-back capacitor bank inrush making current is mandatory for switches that have a rated back-to-back capacitor bank breaking current.

NOTE – The frequency of the inrush current for back-to-back capacitor banks may be in the range of 2 kHz to 30 kHz. The specific values are dependent upon the size and configuration of the capacitor bank being switched, the supply side capacitor bank and the inclusion of limiting impedances, if any.

The switch is not necessarily rated to break the inrush making current produced by the back-to-back capacitor back installation.

4.109 Rated earth fault breaking current (I_{6a})

The rated earth fault breaking current, for an isolated neutral or resonant earthed system, is the maximum earth fault current in the faulted phase that the switch shall be capable of breaking at its rated voltage.

NOTE – The TRV of an isolated neutral system is more severe than the TRV of a resonant earthed system, even if detuned; therefore, for test purposes an isolated neutral system is assumed.

4.110 Rated cable- and line-charging breaking current under earth fault conditions (I_{6b})

The rated cable- and line-charging breaking current under earth fault conditions, for an isolated neutral or resonant earthed system, is the maximum current in the sound phases that the switch shall be capable of breaking at its rated voltage.

NOTE – The maximum cable- and line-charging current under fault conditions is $\sqrt{3}$ times the cable- and line-charging current occurring in normal conditions. This covers the most severe case, which occurs with individually screened cables.

4.111 Rated motor breaking current for special purpose switches (I_7)

The rated motor breaking current is the maximum steady-state current of a motor the switch shall be capable of opening at its rated voltage. Refer to IEC 61233.

Unless otherwise specified, the breaking current for the condition of a stalled motor is eight times the rated normal current of the motor.

4.112 Rated short-circuit making current (I_{ma})

The rated short-circuit making current is the maximum peak prospective current that the switch shall be capable of making at its rated voltage.

4.113 Rated breaking and making currents for a general purpose switch

A general purpose switch shall have specific ratings for each switching duty as follows:

- rated mainly active load-breaking current equal to the rated normal current;
- rated no-load transformer breaking current equal to 1 % of the rated normal current;
- rated distribution line loop-breaking current equal to the rated normal current;

- rated cable-charging breaking current as shown in table 1;
- rated line-charging breaking current as shown in table 1;
- rated short-circuit making current equal to the rated peak withstand current. The switch shall have a capability of closing successfully two or more times at the rated making current.

Switches intended for use in isolated neutral systems or in systems earthed by a high impedance shall have a rated earth fault breaking current and a rated cable and line charging breaking current under earth fault conditions.

The standard values of ratings should be selected from the R10 series specified in IEC 60059.

If an earthing switch, forming an integral part of a switch, has a rated short-circuit making current, this rated current shall be equal to the rated peak withstand current of the switch, unless otherwise agreed to between the manufacturer and user.

NOTE – The R10 series comprises the number 1 - 1,25 - 1,6 - 2 - 2,5 - 3,15 - 4 - 5 - 6,3 - 8 and their products of 10^n.

4.114 Ratings for limited purpose switches

A limited purpose switch shall have a rated normal current, a rated short-time withstand current, and one or more, but not all, switching capabilities of a general purpose switch. If other ratings are specified, values from the R10 series should be selected.

4.115 Ratings for special purpose switches

A special purpose switch shall have a rated normal current, a rated short-time withstand current, a rated short-circuit making current and may have one or more switching capabilities of a general purpose switch.

Ratings and capabilities shall be assigned for the specific special service application for which it is applied. The rated values should be selected from the R10 series. One or more of the following ratings and capabilities may be assigned:

- parallel power transformer breaking capacity;
- single capacitor bank breaking capacity;
- back-to-back capacitor bank breaking capacity and inrush making current;
- motor breaking capacity.

A special purpose switch shall have a short-circuit rated making current as stated in 4.112. This short-circuit making current may be less than the rated peak withstand current.

4.116 Ratings for switches backed by fuses

Short-circuit ratings, short-time withstand currents, and making currents of switches may be selected by consideration of the limiting effect on the duration and value of the short-circuit current by fuses. Current limiting fuses and certain other classes of fuses can be utilized. The associated fuse having the highest rated normal current shall be the basis for establishing a rating. Refer to IEC 60420.

5 Design and construction

Clause 5 of IEC 60694 is applicable, with the additions and exceptions indicated below.

5.1 Requirements for liquids in high-voltage switches

Subclause 5.1 of IEC 60694 is applicable.

5.2 Requirements for gases in high-voltage switches

Subclause 5.2 of IEC 60694 is applicable.

5.3 Earthing of high-voltage switches

Subclause 5.3 of IEC 60694 is applicable.

5.4 Auxiliary and control equipment

Subclause 5.4 of IEC 60694 is applicable.

5.5 Dependent power operation

Subclause 5.5 of IEC 60694 is applicable with the following limitation.

Dependent manual operation is allowable only for limited purpose switches not having a short-circuit making capability.

5.6 Stored energy operation

Subclause 5.6 of IEC 60694 is applicable.

5.7 Independent manual operation

Subclause 5.7 of IEC 60694 is applicable.

5.8 Operation of releases

Subclause 5.8 of IEC 60694 is applicable.

5.9 Low- and high-pressure interlocking and monitoring devices

Subclause 5.9 of IEC 60694 is applicable.

5.10 Nameplates

Subclause 5.10 of IEC 60694 is applicable. Switches and their operating devices shall be provided with nameplates which contain information in accordance with table 2.

5.11 Interlocking devices

Subclause 5.11 of IEC 60694 is applicable.

5.12 Position indication

Subclause 5.12 of IEC 60694 is applicable.

The open and closed positions of the switches shall be clearly indicated. This requirement is met if one of the following conditions is fulfilled:

a) the gap or isolating distance is visible;

b) the position of each movable contact is indicated by a reliable indicating device.

NOTE 1 – A visible moving contact may serve as the indicating device.

NOTE 2 – In the case of a group operated switch (all poles are operated as a single unit), it is permissible to use a common indicating device.

NOTE 3 – The reliable indicating device is specified in IEC 60129.

5.13 Degrees of protection by enclosures

Subclause 5.13 of IEC 60694 is applicable.

5.14 Creepage distances

Subclause 5.14 of IEC 60694 is applicable for outdoor equipment. No specific requirements for creepage distance are given for indoor equipment.

5.15 Gas and vacuum tightness

Subclause 5.15 of IEC 60694 is applicable.

5.16 Liquid tightness

Subclause 5.16 of IEC 60694 is applicable.

5.17 Flammability

Subclause 5.17 of IEC 60694 is applicable.

5.18 Electromagnetic compatibility (EMC)

Subclause 5.18 of IEC 60694 is applicable.

5.101 Making and breaking operations

All switches shall be designed so as to be capable of making the circuits to which their rated making current apply.

All switches shall be designed so as to be capable of breaking at the assigned recovery voltage any current up to and including their rated breaking currents.

5.102 Requirements for switch-disconnectors

Switch-disconnectors shall, in addition, comply with the requirements specified for disconnectors in IEC 60129.

5.103 Mechanical strength

Switches shall be capable of bearing mechanical terminal loads as specified by the manufacturer, when installed according to the manufacturer's instructions, as well as electromagnetic forces, without reduction of their reliability or current-carrying capacity.

5.104 Securing the position

Switches, including their operating devices, shall be so constructed that they cannot come out of their open or closed positions by forces arising from gravity, vibration, reasonable shocks or accidental touching of the connecting rods of their operating devices, or by electromagnetic forces.

Switches or their operating devices shall be designed to allow the application of means to prevent unauthorized operation.

5.105 Auxiliary contacts for signalling

Signalling of the closed position shall not take place until it is certain that the movable contacts will reach a position in which the rated normal current, peak withstand current and short-time withstand current can be carried safely.

Signalling of the open position shall not take place until the movable contacts have reached a position such that the corresponding gap or isolating distance is at least 80 % of the total isolating distance, or until it is certain that the movable contacts will reach their fully open position.

6 Type tests

Clause 6 of IEC 60694 is applicable, with the additions and exceptions indicated below.

6.1 General

The purpose of type tests is to prove the characteristics of high-voltage switches, their operating devices and their auxiliary equipment.

Type tests include:

a) normal type tests:
   - dielectric tests including lightning impulse withstand tests, power-frequency voltage withstand tests, and power-frequency voltage withstand tests on auxiliary and control circuits;
   - temperature-rise tests;
   - measurement of the resistance of the main circuit;
   - short-time withstand current and peak withstand current tests;
   - tests to prove the ability of the switch to make and break the specified currents;
   - tests to prove satisfactory mechanical operation and endurance;
   - verification of the protection;
   - tightness tests;
   - electromagnetic compatibility (EMC) tests.

All of the above tests, except measurement of the resistance of the main circuit, shall be made on complete high-voltage switches (filled with the specified types and quantities of liquid or gas at specified density or reduced density, as required), and on their operating devices and auxiliary equipment.

b) special tests upon special request of the user:
   - tests to prove the ability of the switch to make or break currents that are specified by the user or are beyond the scope of the normal type tests;
   - tests to prove satisfactory operation under severe ice conditions;
   - tests to prove the integrity of the external insulation under conditions of air pollution;
   - tests to verify that switches installed in systems where cable is connected to the switch can withstand the d.c. test voltages normally applied for the dielectric testing of cables. The a.c. voltage on the supply side of the switch should be considered when determining test voltages.

6.1.1 Grouping of tests

Subclause 6.1.1 of IEC 60694 is applicable for normal type tests. Additional test samples may be used for additional type tests.

6.1.2 Information for identification of specimens

Subclause 6.1.2 of IEC 60694 is applicable.

6.1.3 Information to be included in the type-test report

Subclause 6.1.3 of IEC 60694 is applicable.

6.2 Dielectric tests

Subclause 6.2 of IEC 60694 is applicable with the following exception:

6.2.8 Artificial pollution test

Subclause 6.2.8 of IEC 60694 is applicable for outdoor equipment. No tests are required for indoor equipment.

6.2.9 Partial discharge tests

Subclause 6.2.9 of IEC 60694 is replaced by the following:

No partial discharge tests are required to be performed on the complete high voltage switch. However, switch components shall comply in this respect with their relevant IEC publications.

6.3 Radio interference voltage (RIV) tests

RIV tests are not required.

6.4 Measurement of the resistance of the main circuit

Subclause 6.4 of IEC 60694 is applicable.

6.5 Temperature-rise tests

Subclause 6.5 of IEC 60694 is applicable.

6.6 Short-time withstand current and peak withstand current tests

Subclause 6.6 of IEC 60694 is applicable.

6.7 Verification of the protection

Subclause 6.7 of IEC 60694 is applicable.

6.8 Tightness tests

Subclause 6.8 of IEC 60694 is applicable.

6.9 Electromagnetic compatibility (EMC) tests

Subclause 6.9 of IEC 60694 is applicable.

6.101 Making and breaking tests

6.101.1 Arrangement of the switch for tests

The switch under test shall be completely mounted on its own support, or on an equivalent support. Its operating device shall be operated in the manner prescribed and in particular, if it is electrically or pneumatically operated, it shall be operated at the minimum supply voltage or air pressure, respectively.

Before commencing making and breaking tests, no-load operations shall be made, and details of the operating characteristics of the switch such as speed of travel, closing time and opening time shall be recorded.

If applicable, tests shall be performed at the minimum functional pressure of the gas for interruption.

Switches with dependent manual operation may be operated by remote control and power-operating means such that the movement of the contacts is equivalent to that of the manual operator. The manufacturer shall indicate the required minimum speed of the contacts after they have separated. A representative number of making and breaking tests (50 % of each test duty) shall be performed at the minimum operating force.

Switches with independent manual operation may be operated by an arrangement provided for the purpose of making remote control possible.

Consideration shall be given to the effects of energization of either terminal of the switch. When the switch in service can be supplied or energized from either terminal, and the physical arrangement of one side of the switch differs from that of the other side, the supply side of the test circuit shall be connected to the side that represents the most onerous conditions. In case of doubt, 50 % of the total number of close-open operations of each test duty shall be carried out with supply side of the test circuit connected to one side of the switch and the remaining 50 % of each test duty shall be made with the supply connected to the other side.

Making and breaking tests on three-pole operated switches shall be made three-phase except as noted for capacitive current switching tests. Making and breaking tests on three-pole switches operated pole-after-pole, or single-pole switches applied on three-phase systems, may be performed single-phase.

For switches normally installed within a metal enclosure, and having the characteristic of the emission of flame or metallic particles during breaking or making, the following procedure is required. The tests shall be made with the switch mounted within the metal enclosure or with metallic screens placed in the vicinity of the live parts, and separated from them by a clearance which the manufacturer shall specify. The screens, frame and other normally earthed parts shall be insulated and then connected to earth through a fuse consisting of a copper wire of 0,1 mm diameter and 5 cm in length. The fuse wire may also be connected to the secondary side of a 1:1 ratio current transformer. The terminals of the current transformer should be protected by a spark gap or surge arrester. No significant leakage is assumed to have occurred if this wire is intact after the test. Other methods to sense excessive leakage current may also be used.

6.101.2 Earthing of test circuit and switch

Making and breaking tests, with the exception of capacitive current switching tests, conducted on three-pole operated switches, shall be performed using a three-phase test circuit with either the neutral point of the supply earthed, or the neutral point of the load earthed. In either case, the test circuit and the frame of the switch shall be earthed so that the voltage conditions between live parts and earth, and across the switch, after arc extinction, are representative of service voltage conditions.

For single-phase breaking tests on three-pole switches operated pole-after-pole, or for tests on single-pole switches applied on three-phase systems, tests shall be performed with one terminal of the pole to be tested connected to the supply, and the other terminal connected to the load. The common-side connection of the load and supply may be earthed, as shown in figure 2 and figure 4, for example. For capacitive tests circuits, refer to 6.101.8.4.

For test currents requiring both the supply and load neutrals to be earthed, the supply zero sequence impedance shall be less than three times the supply side positive sequence impedance.

The connections used in all tests shall be indicated in the test report.

NOTE – The recommended earthing connections for general purpose switches are based upon the condition that, for rated voltages below 52 kV, many operating systems are unearthed (supply or load or both). For capacitive current switching, tests should be conducted so as to establish ratings for the specific application and earthing conditions.

6.101.3 Test frequency

Switches shall be tested at rated frequency, with a tolerance of ±10 %. However, for convenience of testing, some deviations from the above tolerance are allowable; for example, when switches rated at 50 Hz are tested at 60 Hz and vice versa. Care should be exercised in the interpretation of the results, taking into account all significant facts, such as the type of switch and the type of test performed.

NOTE – In some cases, the rated characteristics of a switch may be different for use at 60 Hz than for use at 50 Hz.

6.101.4 Test voltage for breaking tests

The power-frequency test voltage for three-phase tests shall be equal to the rated voltage of the switch except as noted for specific test duties as shown in table 5. Test voltages for single-phase tests on three-pole operated switches for capacitive current switching are given in item b) of 6.101.8.4.

If single-phase tests on three-pole switches operated pole-after-pole or single-pole switches applied on three-phase systems are performed, they shall be conducted in accordance with the values specified in table 6.

The test voltage shall be measured immediately after interruption, with the exception of capacitive loads, where the voltage is measured immediately prior to opening of the contacts. The voltage shall be measured as closely as possible to the terminals of the switch, i.e. without appreciable impedance between the measuring point and the terminals. For three-phase tests, the test voltage shall be expressed as the average of the phase-to-phase test voltages. The test voltage between any two phases shall not be different from the average test voltage by more than 10 %.

The power-frequency test voltage shall be maintained for at least 0,3 s after arc extinction.

6.101.5 Breaking current

The current to be interrupted shall be symmetrical with negligible decrement. The contacts of the switch shall not be separated until transient currents due to closing of the circuit have subsided.

NOTE – The value of the d.c.-component of the breaking current is considered negligible when the d.c.-component is equal to or less than 20 %.

The breaking current for three-phase tests shall be as noted in table 5, and is measured as the average of the current interrupted in all poles.

The difference between the average current and the values obtained in each pole shall not exceed 10 % of the average value.

The breaking currents for single-phase tests shall be as shown in table 6.

The waveform of the test current for capacitive current switching tests should be sinusoidal. This requirement is satisfied if the ratio of the r.m.s. value of the total current to the r.m.s. value of the fundamental component does not exceed 1,2. The test current shall not go through zero more than once per half cycle of power frequency.

The breaking capacity shall be stated in terms of:

a) the test voltage;
b) the breaking current;
c) the circuit power factor;
d) the test circuit;
e) the transient recovery voltage parameters;
f) the number of close-open operating cycles.

6.101.6 Test voltage for short-circuit making tests

Three-phase tests shall be made on three-pole operated switches at the rated voltage of the switch. Test voltages for single-pole switches applied on three-phase systems, or three-pole switches operated pole-after-pole, are shown in table 6.

6.101.7 Short-circuit making current

The short-circuit making current shall be expressed in terms of peak making current and the r.m.s. symmetrical making current. For general purpose switches, the symmetrical r.m.s. value of current in each pole at 0,2 s shall be at least 80 % of the rated short-time withstand current. The duration of the short-circuit current shall be at least 0,2 s.

The switch shall be able to make the current with pre-strike of the arc occurring at any point on the voltage wave. Two extreme cases are specified as follows:

a) making at the peak of the voltage wave, leading to a symmetrical short-circuit current and the longest pre-striking arc;

b) closing at the zero of the voltage wave, without pre-striking, leading to a fully asymmetrical short-circuit current.

The test procedure as outlined in 6.101.10 aims to demonstrate the ability of the switch to fulfill these requirements.

A general purpose switch shall be able to operate at voltages below its rated voltage at which it may actually make with a fully asymmetrical current. The lower limit of voltage, if any, shall be stated by the manufacturer.

The short-circuit making current performance shall be stated in terms of:

a) the test voltage;

b) the making current expressed as a peak value for asymmetrical making and an r.m.s. value for symmetrical making;

c) the short-circuit current duration;

d) the test circuit;

e) the number of making operations.

6.101.8 Test circuits

Breaking and making tests shall be performed using three-phase test circuits or single-phase test circuits as noted in 6.101.1.

6.101.8.1 Mainly active load circuit (test duty 1)

The test circuits, figures 1 and 2, consist of a supply circuit and a load circuit. The supply circuit, representing the total series impedance, shall have series-connected reactance and resistance and shall have a power factor not exceeding 0,2. The impedance of the supply circuit shall be (15 ± 3) % of the total impedance of the test circuit for test duty 1 (at 100 % of the rated current). The same supply circuit impedance shall be used for all tests at reduced current levels.

The impedance representing the supply side circuit may be connected on the source side of the switch, or split on both sides. The prospective transient recovery voltage of the supply circuit, under conditions of a terminal fault, shall not be less severe than those specified in table 3. The load circuit should have a power factor of 0,7 ± 0,05 and shall consist of reactors and resistors connected in parallel. Lower power factors may be used at the discretion of the manufacturer.

NOTE – TRV values for medium voltage systems are currently under study by CIGRE. Values specified for this test duty, therefore, are subject to revision.

6.101.8.2 Closed-loop circuits (test duty 2)

a) Distribution line circuit (test duty 2a)

The tests circuits, figures 3 and 4, shall have series-connected reactors and resistors and a power factor not exceeding 0,3. The load impedance (Z_L) may be on the supply side of the switch, the load side or divided. If the load impedance is on the load side, the supply side impedance (Z_S) should be as low as possible, but not such that the short-circuit current exceeds the making current of the switch. The prospective transient recovery voltages shall be not less severe than those specified in table 4a.

NOTE – TRV values for medium voltage systems are currently under study by CIGRE. Values specified for this test duty, therefore, are subject to revision.

The open circuit, phase-to-phase, test voltage for three-phase tests is 20 % of rated voltage as noted in table 5. Test voltages for single-phase tests on three-pole operated switches operated pole-after-pole, or single-pole switches applied on a three-phase system, are shown in table 6.

b) Parallel power transformer circuit (test duty 2b) for special purpose switches

The test circuits, figure 3 and 4, shall have series-connected reactors and resistors and a power factor not exceeding 0,2. The prospective transient recovery voltages shall be not less severe than those specified in table 4b.

The open-circuit, phase-to-phase, test voltage for three-phase tests on three-pole switches is 15 % of rated voltage as noted in table 7. Test voltages for single-phase tests on three-pole operated switches operated pole-after-pole, or single-pole switches applied on a three-pole phase system, are shown in table 8.

6.101.8.3 No-load transformer circuit (test duty 3)

Tests are not normally required for this duty. If tests are required, it is recommended that a typical transformer is switched.

6.101.8.4 Capacitive circuits (test duties 4a, 4b, 4c and 4d)

a) General

Tests are normally carried out in a laboratory. However, field tests may also be performed. For field tests, the actual lines, cables and capacitor banks shall be used.

For laboratory tests, the lines or cables may be partly or fully replaced by artificial circuits with lumped elements consisting of capacitors, reactors or resistors.

Three-phase tests should be performed. However, single-phase laboratory tests on three-pole operated switches, are permitted for capacitive current switching tests. The specification of the circuits for single-phase capacitor bank current switching tests may be replaced by specification of the switch prospective recovery voltage parameter limits, as given in table 9 and identified in figure 7.

b) Test voltages

The power-frequency test voltages for three-phase tests are given in table 5. Test voltages for single-phase tests on three-pole operated switches shall equal the product of de $U_r/\sqrt{3}$ and one of the following factors. These test voltages are for switches having a pole non-simultaneity equal to or less than 1/6 cycle:

- 1,0 for earthed neutral supply systems for switching of capacitor banks with earthed neutrals and for switching of screened cables;
- 1,1 for earthed neutral supply systems for switching of belted cables;
- 1,2 for earthed neutral supply systems for switching of overhead distribution lines;
- 1,4 for earthed neutral supply systems for switching of unearthed neutral capacitor banks;
- 1,4 for systems other than earthed neutral supply systems for switching of capacitor banks, lines or cables.

For three-pole operated switches with non-simultaneity greater than 1/6 cycle, either three-phase tests may be performed or single-phase tests may be conducted, using the test voltages in table 6 or table 8.

NOTE 1 – Tests at 60 Hz may be used to demonstrate the breaking performance at 50 Hz if no restrikes occur.

NOTE 2 – Tests at 50 Hz may be considered to prove the characteristics at 60 Hz provided that the voltage across the switch is not less during the first 8,3 ms than it would be during a test at 60 Hz with the specified voltage. If restrikes occur after 8,3 ms, due to instantaneous voltage being higher than it would be during a test at 60 Hz with the specified voltage, and the switch has a very low expected probability of restrike, the test duty should be repeated at 60 Hz with a test voltage as prescribed for the 60 Hz test. If no restrikes occur, the switch is considered to have passed the test.

NOTE 3 – The laboratory test circuits representing lines and cables and capacitor banks are not applicable for determining the magnitude of possible overvoltages when restrikes occur. They are adapted to demonstrate the switching performance only.

c) Characteristics of supply circuit

For line and cable charging current breaking tests, the supply side circuit shall be that specified for mainly active load switching tests including TRV control capacitors and resistors.

For single capacitor bank switching, the characteristic of the supply circuit shall be such that the voltage variation is less than 3 %, but the prospective short-circuit current shall not exceed the rated short-time current of the switch. The prospective TRV parameters under condition of a terminal fault shall not be less severe than the TRV parameters specified in table 3.

For back-to-back capacitor bank breaking current tests, the capacitance of the supply circuit and the impedance between the capacitors on the supply and load sides shall be such as to give the rated capacitor bank inrush making current when testing with 100 % of the rated back-to-back capacitor bank breaking current. The prospective transient recovery of the supply circuit, under conditions of a terminal fault, will be dependent upon the capacitance of the supply circuit.

NOTE 4 – If a switch is intended to be used in a network with appreciable lengths of cable on the supply circuit, appropriate additional capacitance may be used on the supply circuit.

NOTE 5 – For back-to-back capacitor bank current switching tests with a switch having a very low expected probability of restrike, and where separate making tests are performed, a lower capacitance of the supply circuit may be chosen for the breaking tests.

d) Earthing of the supply circuit

For three-phase tests, the earthing shall be as follows:

- for tests of a switch intended for use in isolated neutral and resonant earthed systems, the neutral point of the supply side shall be isolated so as to achieve a first pole-to-clear factor of 1,5;

  NOTE 6 – To achieve a first pole-to-clear factor of 1,5, particularly for line-charging current breaking tests, it might be necessary to disconnect the TRV control elements from earth. For very low currents, this should have no influence on the breaking performance. Alternatively, the neutral of the load circuit may be disconnected from earth.

- for tests of a switch intended for use in earthed neutral systems, the neutral point of the supply circuit shall be earthed. The zero sequence impedance shall be less than three times the positive sequence impedance of the supply side.

For single-phase laboratory tests, either terminal of the single-phase supply circuit may be earthed.

e) General characteristics of the capacitive circuits to be switched

For three-phase tests, the earthing of the capacitive circuit to be switched shall be such as to conform to the applications for which the switch is intended.

The characteristics of the capacitive circuit, with all necessary measuring devices such as voltage dividers included, shall be such that the voltage decay on the switched capacitance does not exceed 10 % at the end of an interval of 300 ms after final arc extinction. This requirement does not apply for field tests.

NOTE 7 – Since the voltage decay may be very much influenced by apparatus such as voltage transformers connected to the capacitive circuit, the measurement should be made with suitable voltage dividers.

f) Cable-charging circuit (test duty 4a)

Capacitors may be used to simulate screened and belted cables. Belted cables are typically used at system voltages up to and including 15 kV. For three-phase tests with an earthed neutral supply, representing three-core belted cables, the positive sequence capacitance of the capacitance circuit shall be approximately equal to two times the zero sequence capacitance. For an unearthed supply neutral, this requirement is not necessary.

When capacitors are used to simulate cables, a non-inductive resistance, not exceeding 5 % of the capacitive impedance, may be inserted in series with the capacitors. Higher values may unduly influence the recovery voltage. If the peak inrush current is still unacceptably high, then an alternative impedance may be used, provided that the current and voltage conditions at the instant of breaking, and the recovery voltage, do not differ significantly from the specified values.

NOTE 8 – A short overhead line may be used in series with the cable for the tests, provided the line-charging current does not exceed 1 % of the cable-charging current.

NOTE 9 – The use of capacitors to simulate cables may not accurately reflect field conditions depending upon the characteristics of the switching device.

g) Line-charging circuit (test duty 4b)

Capacitors may be used to simulate lines. For three-phase tests, with an earthed neutral supply, the positive sequence capacitance of the capacitive circuit shall be approximately three times the zero sequence capacitance. For an unearthed neutral supply, this requirement is not necessary.

When capacitors are used to simulate overhead lines, a non-inductive resistance, not exceeding 5 % of the capacitive impedance, may be inserted in series with the capacitors. Higher values may unduly influence the recovery voltage. If the peak inrush current is still unacceptably high, then an alternative impedance may be used instead, provided that the current and voltage conditions at the instant of breaking, and the recovery voltage, do not differ significantly from the specified values.

NOTE 10 – A short cable may be used in series with an overhead line for the tests, provided the cable-charging current is less than 20 % of the overhead-line charging current.

NOTE 11 – The use of capacitors to simulate overhead lines may not accurately reflect field conditions depending upon the characteristics of the switching device.

h) Capacitor bank circuits (test duty 4c and 4d) for special purpose switches

For three-phase tests, the neutral of the capacitor bank shall be isolated or earthed, depending upon the rating or use of the switch and the earthing of the neutral of the supply circuit.

6.101.8.5 Test circuits for short-circuit making tests (test duty 5)

The test circuit for three-phase tests shall be as shown in figure 5. Single-phase tests on three-pole switches operated pole-after-pole, or single-pole switches applied on three-phase systems may use a single-phase test circuit as shown in figure 6.

6.101.8.6 Test circuits for earth fault tests (test duties 6a and 6b)

Test circuits according to figures 8 and 9 shall be used with the impedance Z_S equal to the impedance of the supply side for test duty 1 for general purpose switches.

Non-inductive resistors R having a resistance not exceeding 5 % of the capacitive impedance may be inserted in series with the capacitors.

6.101.8.7 Motor circuits (test duty 7)

IEC 61233 is applicable.

6.101.9 Breaking tests for general purpose switches

The required number of operations, test voltages, and tests currents for class E1, E2 and E3 switches are given in table 5 for three-phase tests and in table 6 for single-phase tests. Test duties 1 through 4 and, if applicable, test duty 6 shall be performed on the same switch but may be performed in any convenient order. The tests shall be performed without reconditioning of the switch during the test program.

Make-break operating cycles shall be carried out for test duties 1 through 4 and 6. The opening operation shall follow the closing operation with a time delay between the two operations at least sufficient for any transient currents to subside. The opening and closing operations can be separated when design features of the switch or limitations of the test plant require it. The time interval between closing and opening shall not normally exceed 3 min. For convenience, open-close operations may also be performed. The breaking currents shall be in accordance with 6.101.5.

NOTE 1 – If the TRV parameters achieved in test duty 1 are equal to or more severe than TRV parameters required for test duty 2a, then test duty 2a need not be performed provided 10 additional operations for class E1 switches or 20 for class E2 and E3 switches are performed for test duty 1 at 100 % *I*.

NOTE 2 – Tests are not normally required for no-load transformer switching since the stress associated with this duty is negligible and is easily performed for a switch capable of switching active load. If tests are required, the number of tests to be performed shall be determined upon agreement between manufacturer and user.

NOTE 3 – Switches with a rated cable-charging current for application on other than earthed neutral systems need not be tested for cable-charging currents in earthed neutral systems.

NOTE 4 – Switches with a rated cable-charging current for belted cables for application on earthed neutral systems need not be tested on cable-charging currents for screened cables if the current ratings for this duty are equal to or less than that for belted cables.

If the rated cable-charging current breaking tests have been proven by utilizing a test circuit yielding a first pole-to-clear factor equal to or greater than produced for a line-charging current breaking test circuit, then tests for line-charging current need not be performed if the line-charging current ratings are equal to or less than those for cable-charging current as listed in table 1.

6.101.10 Short-circuit making tests for general purpose switches

Short-circuit making tests shall be performed on a switch which has been subjected to at least 10 make-break operating cycles at 100 % mainly active load as required for test duty 1. However, if it can be demonstrated that the short-circuit making performance cannot be affected by the breaking test specified, then for convenience, test duty 5 may be performed on a new switch.

Due to pre-arcing, it is not always possible to achieve the required rated short-circuit making current. In this case, evidence shall be given that the making currents attained are representative of the currents which will be achieved upon application of the switch at rated voltage in a circuit wherein the maximum prospective peak current is equal to the rated short-circuit making current.

This evidence may be given in the following way. From test duties 1 and 2 it may be possible to collate sufficient statistical data to allow the determination of the conditions of pre-arcing where the maximum peak making current can be expected in test duty 5. (If sufficient data cannot be determined from test duties 1 and 2, then a suitable number of closing operations should be carried out with 5 % to 10 % of the a.c.-component of the rated making current.)

a) Make time scatter equal to or less than 3 ms

The closing operations are carried out in a circuit with 100 % prospective peak making current with point-on-wave control corresponding to the above conditions so as to produce the maximum possible peak making current.

b) Make time scatter greater than 3 ms.

In this case point-on-wave control may be inadequate. The closing operations are carried out in a circuit with 100 % prospective peak making current, with or without point-on-wave control. If the conditions of the test such as to produce the maximum possible peak making current are not reproduced, the performance being otherwise satisfactory, then, depending upon the class of the switch, additional short-circuit making tests should be carried out: 1 for class E1, 2 for class E2 and 3 for class E3. The manufacturer is permitted to recondition the switch prior to these additional making tests.

1) Three-phase tests

For three-phase tests on a three-pole operated switch, it is assumed that the requirements outlined in items a) and b) of 6.101.7 are adequately demonstrated during the normal test duty 5.

2) Single-phase tests

For single-phase tests, the making tests shall be carried out in such a way that the requirement outlined in item b) of 6.101.7 is met in one test for class E1 switches, two tests for class E2 switches, three tests for class E3 switches, and that of item a) in the other making operations. The sequence of these operations is not specified.

6.101.11 Tests for limited purpose switches

The tests specified for general purpose switches shall be used, deleting those test-duties for which the switch is not rated or by reducing the test values according to the limited ratings.

6.101.12 Tests for special purpose switches

The tests for special purpose switches are given in table 7 for three-phase tests and in table 8 for single-phase tests. Special purpose switches shall also be tested in accordance with the tests specified for general purpose switches deleting the test duties for which the switch is not rated.

The making current for the back-to-back capacitor bank current switching test should be equal to the rated capacitor bank inrush making current. Due to limitations of the test plant for back-to-back capacitor bank switching tests, it may not be possible to comply with the requirements of inrush current during breaking tests. For switches having a very low expected probability of restrike, it is permissible to perform an alternative breaking test procedure wherein the breaking test requirements according to 6.101.8.4 are met to the best possible extent. A separate making test series may then be performed before the breaking tests. This test series should be made with the proper voltage and should comprise 10 making operations with a prospective making current equal to the rated capacitor inrush making current. The making shall occur within 15 electrical degrees of peak voltage.

NOTE – If test duty 1 is performed with at least the rated closed-loop breaking current for parallel power transformers and the TRV parameters achieved are equal to, or more severe than, the TRV parameters required for test duty 2b, then test duty 2b need not be performed provided 10 additional operations are performed for test duty 1.

6.101.13 Behaviour of switch during breaking tests

The switch shall perform successfully without evidence of mechanical or electrical distress.

For capacitive current breaking tests, restrikes are permitted during switching if the switch is not specified as a switch having a very low expected probability of restrike. There shall be no flame or material ejected from the switch, or audible noise generated that may be harmful to operating personnel.

There shall be no outward emission of flame or metallic particles from the switch during operation such as might impair the insulation level of the switch.

There shall be no significant leakage current to the earthed structure or screens, such as to endanger an operator or damage insulation materials. This may be verified by following the procedure specified in 6.101.1.

For vacuum switches, a maximum of three non-sustained disruptive discharges (NSDD) are allowed during the entire test program. A NSDD is defined as a disruptive discharge between the contacts of the switch during the power-frequency recovery voltage period resulting in only a high-frequency current flow. A resumption of power-frequency current is not allowed.

6.101.14 Condition of switch after breaking tests and short-circuit making tests

After performing the specified test duties 1 through 4, and 6, and after test duty 5, the mechanical function and the insulators of the switch shall be in practically the same condition as before the tests. The switch shall be capable of carrying its rated normal current without its temperature rise exceeding the values specified. Condition checking after breaking tests is not necessary if short-circuit making tests are made on the same test sample.

Visual inspection and no-load operation of the switch after tests are usually sufficient for checking these requirements. In case of doubt, two additional close-open operations shall be made with the rated normal current.

If the insulating properties across open contacts of a switch or the isolating properties of a switch-disconnector are doubted, a condition check test according to 6.2.11 of IEC 60694 is deemed sufficient to verify these properties. For switches with sealed-for-life interrupters, the condition checking test is mandatory unless the sealed interrupter may be disassembled or opened for the purpose of inspection.

6.101.15 Type test reports

The results of all type tests shall be recorded in type-test reports containing sufficient data to prove compliance with this standard. Sufficient information should be included so that the essential parts of the high-voltage switch tested can be identified. Refer to clause 6.1.2 of IEC 60694.

The test report shall contain the information specified in 6.101.2, 6.101.4, 6.101.5, 6.101.6 and 6.101.7. Typical oscillographic or similar records should be provided so that the following can be determined:

1) the test currents;
2) the test voltage;
3) the voltages across the terminals of each pole, so that the power-frequency recovery voltages and transient recovery voltages may be determined;
4) if applicable, the instant of energizing the trip and closing coil.

NOTE – If requested by the user, a complete set of oscillograms should be included in the test report or made available to the user.

General information concerning the supporting structure of the high-voltage switch should be included. Information regarding the operating devices employed during the tests should, where applicable, be recorded.

6.102 Mechanical operation tests

6.102.1 Arrangement of the switch for tests

The switch should be mounted on its own support and its operating mechanism shall be operated in the specified manner.

Unless otherwise specified, the tests may be made at any convenient ambient air temperature.

The supply voltage of the operating device shall be measured at the terminals of the closing and tripping coils during operation of the switch. Auxiliary equipment forming part of the operating device shall be included. Impedance shall not be added between the supply and the terminals of the device for regulation of the applied voltage.

For manually operated switches, the handle may, for convenience of testing, be replaced by an external power device where the operating force is equivalent to that for operation with a manual handle.

6.102.2 Test for general purpose switches

Switches tested according to this subclause are designated class M1 mechanical endurance.

The mechanical operation tests shall consist of 1 000 operating cycles without voltage on, or current in, the main circuit. If a capability beyond 1 000 operating cycles is required for all classes of switches, extended mechanical endurance tests should be conducted in accordance with 6.102.4.

A switch having a power-operating device shall be subjected to the following tests:

- 900 operating cycles at rated supply voltage and/or rated pressure of compressed gas supply;
- 50 operating cycles at the specified minimum supply voltage and/or minimum pressure of compressed gas supply;

- 50 operating cycles at the specified maximum supply voltage and/or maximum pressure of compressed gas supply.

  A manually operated switch shall be subjected to the following test: 1 000 operating cycles using a range of operating forces typical of that to be expected in service.

No specific time intervals between operating cycles or between closing and opening operations are required. These tests shall be made, however, at a rate such that the temperature rises of the energized electrical control components do not exceed the specified values.

6.102.3 Tests for limited purpose switches

Unless otherwise specified, the tests performed shall be in accordance with the tests required for a general purpose switch. Alternatively, tests may be performed by agreement between manufacturer and user.

6.102.4 Extended mechanical endurance tests on switches for special service requirements

Switches tested according to this subclause are designated class M2 mechanical endurance.

For special service requirements, extended mechanical endurance tests may be carried out as follows. The user should specify.

a) The tests shall be made according to 6.102.2 with the following addition: 5 000 operating cycles shall be performed comprising five times the test series specified in the 6.102.2.

   Between the test series specified, some maintenance such as lubrication and mechanical adjustment is allowed and shall be performed in accordance with the manufacturer's instructions. Change of contacts is not permitted.

   The program of maintenance during the tests shall be defined by the manufacturer before the test and recorded in the test report.

b) Before and after the total test program, the following operations shall be performed:
   - five close-open operating cycles at the rated supply voltage and/or pressure;
   - five close-open operating cycles at the minimum supply voltage and/or pressure;
   - five close-open operating cycles at the maximum supply voltage and/or pressure;
   - five close-open manual operations if the switch can be manually operated besides its normal electric or pneumatic operating device.

   During these operating cycles, operating characteristics shall be recorded or evaluated, if applicable, such as operating times, consumption of the control circuit, maximum forces for manual operation; satisfactory operation of control and auxiliary contacts, and position-indicating devices (if any) shall be verified. It is not necessary to include all the oscillograms recorded in the type test report.

c) After each series of 1 000 operating cycles or at maintenance intervals, some significant operating characteristics should be recorded or evaluated.

NOTE – The extended mechanical endurance tests do not apply to manually operated switches.

6.102.5 Condition of switch during and after mechanical operation tests

The fully closed and fully open positions shall be attained during each operating cycle.

The switch shall be in such a condition that it is capable of operating normally, making, carrying and breaking its rated normal current.

Satisfactory operation of operating devices, of control and auxiliary contacts, and of position-indicating devices (if any), shall be verified during the test.

For switches having gas as an interrupting and insulating medium, a tightness test shall be performed before and after the mechanical operation test. See 6.8 of IEC 60694.

Lubrication in accordance with the manufacturer's instructions is permissible during the test, but mechanical adjustments are not permitted.

After the tests, all parts shall be in good condition and shall not show excessive wear.

6.103 Operation under severe ice conditions

If required, tests shall be performed in accordance with 6.103 of IEC 60129, with the following exception:

6.103.1 Checking of operation

Switches having stored energy or dependent power-operating mechanisms shall operate successfully on the first attempt to operate.

Switches having dependent manual operation must operate successfully on opening or closing; that is, satisfactorily open or close the circuit safely. However, if the switch is bounded by ice and does not move on the first attempt to operate, additional attempts to operate are permissible.

7 Routine tests

Clause 7 of IEC 60694 is applicable with the following addition.

7.101 Mechanical operating tests

Operating tests are made to ensure that switches comply with the prescribed performance within the specified supply voltage and pressure limits of their operating devices.

During these tests, which are performed without voltage or current in the main circuit, it shall be verified, in particular, that the switches open and close correctly when their operating devices are energized or under pressure. It shall also be verified that operation will not cause any damage to the switches.

The arrangement of the switch shall comply with specifications for the mechanical operation type tests, refer to 6.102.1.

A switch having a power-operating device shall be subjected to the following tests:

at specified maximum supply voltage and/or maximum pressure of compressed gas supply: five operating cycles;

- at specified minimum supply voltage and/or minimum pressure of compressed gas supply: five operating cycles;
- if a switch can be manually operated besides its normal electric or pneumatic operating device: five manual operating cycles.

A manually operated switch shall be subjected to the following test: 10 operating cycles.

During these tests, no adjustment shall be made and the operation shall be faultless. The closed and open positions shall be attained during each operating cycle.

8 Guide to the selection of high-voltage switches for service

8.1 General

This guide presents suggestions on application as an aid to obtaining satisfactory performance of high-voltage switches rated less than 52 kV.

It is offered in recognition of the continuing need for general guidelines to supplement, but not replace, the manufacturer's detailed instructions.

Refer to 2.1 of IEC 60694 for normal service condition requirements.

8.2 Conditions affecting application

Where unusual conditions exist, they should be brought to the attention of the manufacturer for his recommendations. Examples of such conditions are:

a) contamination such as damaging fumes or vapour, excessive or abrasive dust, explosive mixtures of dust or gases, salt spray, excessive moisture or dripping water, etc.;
b) abnormal vibration, shocks, tilting, or seismic activity;
c) excessively high or low ambient temperatures;
d) unusual transportation or storage conditions;
e) unusual space limitations;
f) mounting positions other than those recommended by the manufacturer;
g) high altitude;
h) wind velocity in excess of normal service conditions;
i) unusual operating duty, frequency of operation, difficulty of maintenance, unbalanced voltages, special insulation requirements, etc.;
j) for use at other than rated frequency, such as harmonics associated with capacitor banks, and rectifier circuits. The normal current rating of the switch should be such as to adequately carry the power-frequency current and the harmonic currents.

Refer to 2.2 of IEC 60694 for special service conditions.

8.3 Insulation coordination

The rated insulation level of a switch shall be selected according to 4.2 of IEC 60694.

Refer to IEC 60071-1 for a general discussion and recommendations on insulation coordination.

8.4 Selection of class of switch

8.4.1 General purpose switch

Refer to 3.4.103 for purpose and application of class E1, E2, E3, M1 and M2 general purpose switches.

8.4.2 Limited purpose switch

Refer to 3.4.104 for definitions of the capabilities of a limited purpose switch.

8.4.3 Special purpose switch

Refer to 3.4.105 for definition of the capabilities and application of a special purpose switch.

9 Information to be given with inquiries, tenders and orders

9.1 Information to be given with inquiries and orders

When inquiring for or ordering a switch, the following particulars should be supplied by the inquirer:

a) particulars of system: i.e., nominal and highest voltages, frequency, number of phases, and details of neutral earthing. Unusual characteristics of the system in which the switch is to be applied should be noted (harmonic currents, resonance conditions, number of operations required);

b) service conditions including minimum and maximum ambient air temperatures, if beyond the normal values; altitude, if over 1 000 m; and any special conditions likely to exist or arise, e.g. unusual exposure to steam or vapour, moisture, fumes, explosive gases, excessive dust, or salt air (see 2.1, 2.2 and 6.2.8 of IEC 60694 and 8.2 of this standard).

c) characteristics of the switch

   The following information should be given:

   1) number of poles;
   2) type and class of switch as defined in clause 3;
   3) indoor or outdoor installation;
   4) rated voltage (4.1 of IEC 60694);
   5) rated insulation level where a choice exists between different insulation levels corresponding to a given rated voltage or, if other than standard, desired insulation level (4.2 of IEC 60694);
   6) rated frequency (4.3 of IEC 60694);
   7) rated normal current (4.4 of IEC 60694);

   8) rated breaking currents;
   9) rated short-circuit making current;
   10) if other than standard, desired duration of short-circuit current (4.7 of IEC 60694);
   11) the type tests required on special request.

d) characteristics of the operating mechanism of switch and associated equipment, in particular:
   1) method of operation, whether manual or power;
   2) number and type of spare auxiliary switches;
   3) rated supply voltage and rated supply frequency.

e) requirements concerning the use of compressed air and requirements for design and test of pressure vessels.

9.102 Information to be given with tenders

When the inquirer requests technical particulars of a switch, the following information, where applicable, should be given by the manufacturer, with any explanatory text and drawings:

a) rated values and characteristics
   1) Number of poles.
   2) Type and class of switch as defined in clause 3.
   3) Indoor or outdoor application.
   4) Rated voltage (4.1 of IEC 60694).
   5) Rated insulation level (4.2 of IEC 60694).
   6) Rated frequency (4.3 of IEC 60694).
   7) Rated normal current (4.4 of IEC 60694).
   8) Rated breaking currents as defined in clause 3 and 4, if applicable.
   9) Rated short-circuit making current as defined in 3.7.114 and 4.112 if applicable.
   10) Rated duration short-circuit current (4.7 of IEC 60694).

b) type tests

   List of certificates or reports on request, including the special tests requested by the inquirer.

c) constructional features
   1) Mass of complete switch.
   2) Gas pressure and limits of gas pressure within which the switch will operate correctly for air blast switches and gas switches (4.10 of IEC 60694).
   3) Minimum clearances in air:
      – between poles;
      – to earth.

d) operating mechanism of switch and associated equipment
   1) Type of operating mechanism.
   2) Rated supply voltage of closing and opening devices (4.8 of IEC 60694).
   3) Rated supply frequency (4.9 of IEC 60694).
   4) Rated pressure of compressed gas supply for operation (4.10 of IEC 60694).
   5) Current required at rated supply voltage to close and open the switch.
   6) Quantity of free air required to close and open the switch at rated supply pressure.
   7) Rated supply voltage of shunt opening release.
   8) Current required at rated supply voltage for shunt opening release.
   9) Number and type of spare auxiliary switch contacts.
   10) Current required at rated supply voltage by other auxiliaries.

e) overall dimensions and other information

   The manufacturer should give the necessary information regarding overall dimensions of the switch and details necessary for installation. General information regarding maintenance should also be given.

10 Rules for transport, storage, erection, operation and maintenance

Clause 10 of IEC 60694 is applicable.

11 Safety

Clause 11 of IEC 60694 is applicable.

Table 1 – Rated line- and cable-charging breaking currents for general purpose switch

Rated voltage U_r kV	Rated cable charging I_{4a} A	Rated line charging I_{4b} A
3,6	4	0,3
4,76*	4	0,3
7,2	6	0,5
8,25*	6	0,5
12	10	1
15*	10	1
17,5	10	1
24	16	1,5
25,8*	16	1,5
36	20	2
38*	20	2
48,3*	24	2,5

* North American values.

NOTE – Higher values selected from the R10 series may be stated by the manufacturer.

Refer to IEC 60056 for suggested higher rated line and cable-charging breaking currents for a special purpose switch.

Table 2 – Nameplate information

(1)	Abbre-viation (2)	Unit (3)	Switch (4)	Operating device (5)	Condition: marking required only if (6)
Manufacturer			x	x	
Designation of type and class			x	x	
Serial number			(x)	(x)	
Rated voltage	U_r	kV	x		
Rated lightning impulse withstand voltage	U_w	kV	x		
Rated frequency	f_r	Hz	x		
Rated normal current	I_r	A	x		
Rated short-time current	I_k	kA	x		
Rated duration of short-time current	t_k	s	y		Different from 1 s
Rated short-circuit making current	I_{ma}	kA	(x)		
Number of operations for mainly active load breaking	n		y		Different from 10
Rated mainly active load breaking current	I_1	A	(x)		
Rated distribution line closed-loop breaking current	I_{2a}	A	(x)		
Rated parallel power transformer breaking current	I_{2b}	A	(x)		
Rated no-load transformer breaking current	I_3	A	(x)		
Rated cable-charging breaking current	I_{4a}	A	(x)		
Rated line-charging breaking current	I_{4b}	A	(x)		
Rated single capacitor bank breaking current	I_{4c}	A	(x)		
Rated back-to-back capacitor bank breaking current	I_{4d}	A	(x)		
Rated earth-fault breaking current	I_{6a}	A	(x)		
Rated cable- and line-charging breaking current under earth-fault conditions	I_{6b}	A	(x)		
Rated motor breaking current	I_7	A	(x)		
Rated back-to-back capacitor bank inrush making current	I_{in}	A	(x)		
Rated pressure for operating device	P_{op}	Pa		(x)	
Rated gas pressure for switch	P_{sw}	Pa	(x)		
Rated auxiliary voltage	U_a	V		x	
Temperature class	TC		y	y	Different from: –5 °C indoor or –25 °C outdoor

x The marking of these values is mandatory; blanks for these values on the nameplate indicate the value zero.

(x) The marking of these values is optional.

y The marking of these values is subject to the condition in column (6).

NOTE 1 – Abbreviations in column (2) may be used instead of terms in column (1). When terms of column (1) are used, the word "rated" need not appear.

NOTE 2 – It is permissible to combine abbreviations where values are identical, for example: I_r, I_1, I_{2a} = 400 A.

NOTE 3 – Different rated currents and short-circuit making currents related to different classes may be given.

Table 3 – Supply circuit TRV parameters for mainly active load current breaking tests[1]

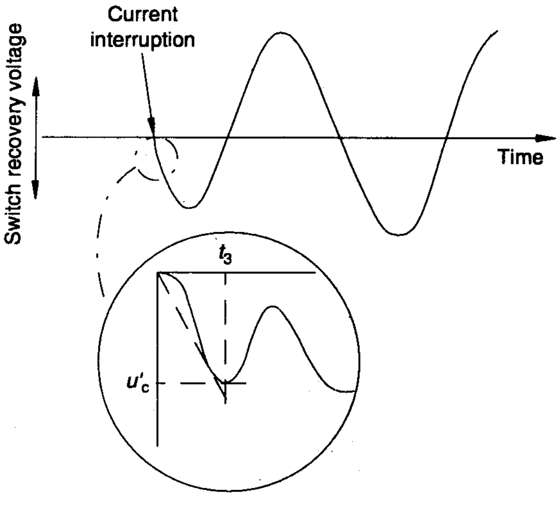
Rated voltage U_r kV	Supply TRV parameters	
	Peak voltage[2] u_c kV	Time coordinate[2] t_3 µs
3,6	6,2	40
4,76[3]	8,2	40
7,2	12,3	52
8,25[3]	14,1	52
12	20,6	60
15[3]	25,7	72
17,5	30	72
24	41	88
25,8[3]	44,2	88
36	62	108
38[3]	65,1	108
48,3[3]	82,8	132

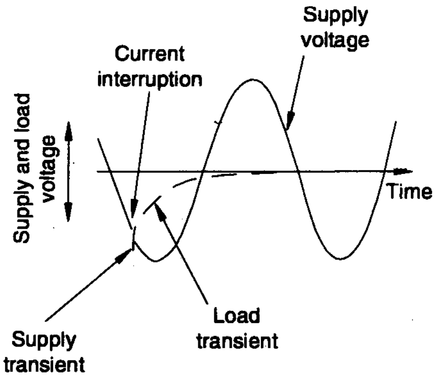
[1] Supply circuit TRV parameters under conditions of a terminal fault.

[2] TRV values for medium-voltage systems are currently under study by CIGRE. Users are cautioned that if current-limiting reactors are used, the supply circuit TRV may exceed the values specified. Values specified for these duties, therefore, are subject to revision.

[3] North American values.

NOTE 1 – The transient recovery voltage across the switch during load current breaking tests is of the (1-cos) form. The switch supply and load transient components are illustrated below. The peak value of the supply component, u'_c as illustrated, will be approximately 15 % of u_c at an approximate time t_3. The actual u'_c and time to peak will be dependent upon the load circuit power factor and series impedance of the supply circuit.





u'_c = peak of supply circuit component of switch transient recovery voltage.

NOTE 2 – The series supply impedance is (15 ± 3) % of the total impedance with a power factor of 0,2 or less. The load consists of parallel resistance and reactance. The TRV from the load is an exponentially decaying voltage whose peak is determined by the power factor of the load. Thus, the load side TRV is completely determined by the load circuit and need not be specified.

NOTE 3 – The series supply impedance is a combination of distributed transformer impedance and remote supply impedance. The first pole-to-clear factor K_φ is 1,5. The amplitude factor is assumed to be 1,4.

$$u_c = \frac{U_r\sqrt{2}}{\sqrt{3}} \times 1{,}5 \times 1{,}4$$

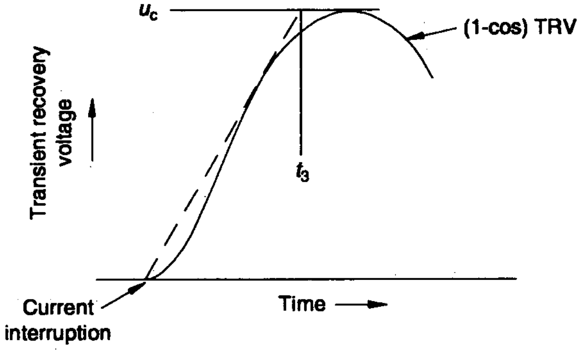
Table 4a – TRV parameters for distribution line closed loop breaking tests

Rated voltage U_r kV	Peak voltage[1] u_c kV	Time coordinate[1] t_3 μs
3,6	1,2	110
4,76[2]	1,7	110
7,2	2,4	110
8,25[2]	2,9	110
12	4,1	150
15[2]	5,1	200
17,5	6,0	200
24	8,3	250
25,8[2]	8,9	250
36	12,3	310
38[2]	13,1	310
48,3[2]	16,5	350

[1] TRV values for medium-voltage systems are currently under study by CIGRE. Values specified for this test duty, therefore, are subject to revision.

[2] North American values.

NOTE 1 – The specified transient recovery voltage across the switch is of the (1-cos) form. A typical transient is illustrated below.



NOTE 2 – Steady-state, phase-to-phase, open-circuit test voltage is 20 % of rated voltage. u_c is based on a system having a first pole-to-clear factor K_φ of 1,5 and an amplitude factor equal to 1,4.

$$u_c = U_r \times (0,20)\sqrt{\frac{2}{3}} \times 1,5 \times 1,4.$$

Table 4b – TRV parameters for parallel power transformer current breaking tests

Rated voltage U_r kV	Peak voltage u_c kV	Time coordinate t_3[1)] *K* factor
3,6	0,6	0,25
4,76[2)]	0,7	0,28
7,2	1,1	0,35
8,25[2)]	1,3	0,38
12	1,9	0,45
15[2)]	2,3	0,50
17,5	2,7	0,55
24	3,7	0,63
25,8[2)]	4,0	0,67
36	5,6	0,78
38[2)]	5,9	0,80
48,3[2)]	7,5	0,90

[1)] The time coordinate is calculated as $t_3 = K\sqrt{\dfrac{1\,480 + 600\,I}{6{,}7\,I}}$

where t_3 is in microseconds and I is the test current in kA. The *K* factor and the formula for t_3 were derived from published transient recovery voltage frequencies obtained by low-voltage current injection of transformers. The frequency is typical of power transformers having a current rating close to the test current and an impedance of 15 % at the forced cooled rating.

[2)] North American values.

NOTE 1 – The transient recovery voltage across the switch is of the (1-cos) form and the values are for the first pole to clear.

NOTE 2 – The first pole-to-clear factor K_φ is 1,5. The amplitude factor is assumed to be 1,7 in accordance with IEC 60056 for short-circuit test duty no. 1. It is assumed that two power transformers are in parallel with one transformer being switched. The TRV is mainly from the transformer being switched. This implies that the transient recovery voltage is based only on half of the steady-state recovery voltage.

$$u_C = \frac{U_r\sqrt{2}}{\sqrt{3}} \times 1{,}5 \times 1{,}7 \times \frac{0{,}15}{2}$$

Table 5 – Test duties for general purpose switches – Test duties for three-phase tests on three-pole operated, pole-after-pole operated, and single pole switches

Test duty		Test voltage[1]	Test current	Number of cycles of operations		
No.	Type	$^{+10}_{\ 0}$ %	$^{+10}_{\ 0}$ %	Class E1	Class E2	Class E3
1	Mainly active load current	U_r	I_1	10	30	100
			0,05 I_1	20	20	20
2a	Closed-loop distribution circuit current	0,20 U_r	I_{2a}	10	20	20
4a	Cable-charging current[2]	U_r	I_{4a}	10[3]	10[3]	10[3]
			0,2 - 0,4 I_{4a}	10[3]	10[3]	10[3]
4b	Line-charging current[2]	U_r	I_{4b}	10[3]	10[3]	10[3]
5	Short-circuit making current	U_r	I_{ma}	2 making operations	3 making operations	5 making operations
6a	Earth fault current	U_r	I_{6a}	10	10	10
6b	Cable- and line-charging current under earth faults	U_r	I_{6b}	10	10	10

[1] TRV parameters are as shown in the appropriate table for the first pole-to-clear.

[2] Supply circuit earthing shall be as stated in item d) of 6.101.8.4.

[3] Point-on-wave tripping to control contact parting may be used; however, random operations are permissible.

Table 6 – Test duties for general purpose switches – Single phase tests on three-pole switches operated pole-after-pole and single-pole switches applied on three-phase systems6)

Test duty		Test voltage1)	Test current	Number of cycles of operations		
No.	Type	$^{+10}_{0}$ %	$^{+10}_{0}$ %	Class E1	Class E2	Class E3
1	Mainly active load current	$1,5\ U_r/\sqrt{3}$	I_1	5	15	50
		U_r 3)	$0,87\ I_1$ 2)	5	15	50
		U_r 3)	$0,05\ I_1$	20	20	20
2a	Closed-loop distribution circuit current	$0,20\ U_r$ 3)	I_{2a}	10	20	20
4a	Cable-charging current	5)	I_{4a}	12 4)	12 4)	12 4)
		5)	$0,2 - 0,4\ I_{4a}$	12 4)	12 4)	12 4)
4b	Line-charging current	5)	I_{4b}	12 4)	12 4)	12 4)
5	Short-circuit making current	U_r	I_{ma}	1 making operation	2 making operations	3 making operations
		U_r	I_{ma}	1 making operation	1 making operation	2 making operations
6a	Earth fault current	$U_r/\sqrt{3}$	I_{6a}	10	10	10
6b	Cable- and line-charging current under earth faults	U_r	I_{6b}	10	10	10

1) TRV values are as specified in appropriate tables.

2) One test series may be performed at rated voltage U_r and rated current I_1, provided 10 operations are performed for class E1, 30 operations for class E2, and 100 operations for class E3 switches.

3) The peak TRV values shall be $\sqrt{3}/1,5$ times the values shown in tables 3 and 4a.

4) Point-on-wave tripping to control contact parting at 30 electrical degree increments. If this is not possible, 30 random operations shall be used.

5) The manufacturer shall select the test circuit to be representative of the intended application. The test voltage shall equal the product of $U_r/\sqrt{3}$ and one of the following factors:

a) 1,0 for earthed neutral systems for switching of screened cables;
b) 1,2 for earthed neutral systems for switching of belted cables;
c) 1,3 for earthed neutral systems for switching of line;
d) 1,75 for systems other than earthed neutral for switching of line and cable.

6) These test duties are not applicable for single-pole switches intended for application in single-phase systems.

Table 7 – Test duties for special purpose switches – Three-phase tests on three-pole operated, pole-after-pole operated, and single-pole switches

Test duty		Test voltage	Test current	Number of cycles of operations
No.	Type	$^{+10}_{0}$ %	$^{+10}_{0}$ %	
2b	Closed-loop parallel power transformer circuit current	0,15 U_{r}1)	I_{2b}	10
4c	Single capacitor bank current3)	U_{r}	I_{4c}	10
			0,2 - 0,4 I_{4c}	10
4d	Back-to-back capacitor bank current3)	U_{r}	I_{4d}	10
			0,2 - 0,4 I_{4d}	10
8	Motor current	2)	2)	2)

1) TRV parameters are as shown in table 4b for the first pole-to-clear.

2) Refer to IEC 61233.

3) Supply circuit earthing shall be as stated in item c) of 6.101.8.4. For test duties 4c and 4d, the capacitor bank neutral shall be isolated or earthed depending upon the application of the switch.

Table 8 – Test duties for special purpose switches – Single phase tests on three-pole switches operated pole-after-pole and single-pole switches applied on three-phase systems6)

Test duty		Test voltage	Test current	Number of cycles of operations
No.	Type	$^{+10}_{0}$ %	$^{+10}_{0}$ %	
2b	Closed-loop parallel power transformer circuit current	0,15 U_{r}1)	I_{2b}	10
4c	Single capacitor bank current	2)	I_{4c}	123)
			0,2 - 0,4 I_{4c}	123)
4d	Back-to-back capacitor bank current	2)	I_{4d}	123), 4)
			0,2 - 0,4 I_{4d}	123)
8	Motor current	5)	5)	5)

1) The peak TRV values shall be $\sqrt{3}/1{,}5$ times the values shown in table 4b.

2) The manufacturer shall select the test circuit to be representative of intended application. The test voltage shall equal the product of $U_{r}/\sqrt{3}$ and one of the following factors:

a) 1,0 for earthed neutral systems for switching of capacitor banks with earthed neutrals;

b) 1,75 for systems other than earthed neutral systems for switching capacitor banks.

3) Point-on-wave tripping to control contact parting at 30 electrical degree increments. If this is not possible, 30 random operations shall be used.

4) At least three of the making operations shall take place within 15 electrical degrees of voltage peak.

5) Refer to IEC 61233.

6) These test duties are not applicable for single-pole switches intended for application in single-phase systems.

Table 9 – Prospective recovery voltage parameter limits for single-phase capacitor bank current breaking tests

Recovery voltage[1), 2)]		Time coordinates[1)]		
u_c[5)]	u_a[4)]	t_a[4)]	t_2[5)] ms	
			50 Hz	60 Hz
1,97	0,042	t_3[3)]	8,7	7,3

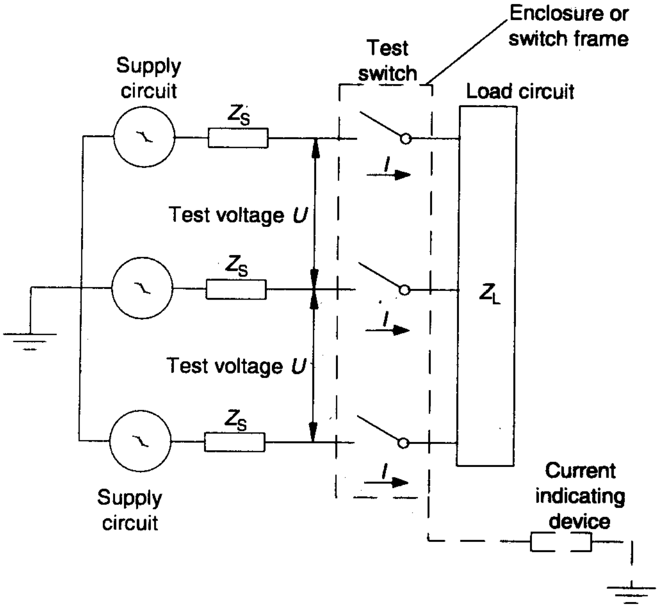
[1)] Refer to figure 7.

[2)] Values are per unit with respect to the peak value of the test voltage.

[3)] t_3 in table 3.

[4)] The peak value u'_a of the initial part of the prospective TRV shall be less than u_a and the time to peak t'_a shall be greater than t_a as shown in figure 7.

[5)] The prospective peak recovery voltage u'_c shall be greater than u_c and the time to peak t'_2 shall be less than t_2 as shown in figure 7.



Test-duty1:

$I = I_1$ and $0{,}05\ I_1$

Supply circuit:

power factor $\leq 0{,}2$

$Z_T = Z_S + Z_L$

$|Z_S| = (0{,}15 \pm 0{,}03)\ |Z_T|$

TRV parameters: table 3

Load circuit:

power factor = 0,65 to 0,75

NOTE – The load impedance circuit neutral may be earthed as an alternate to the supply neutral.

Figure 1a – General circuit

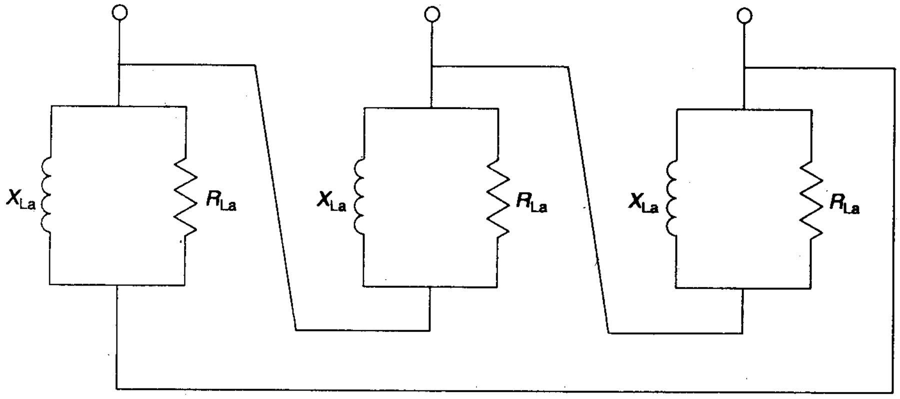


Figure 1b – Delta load connection

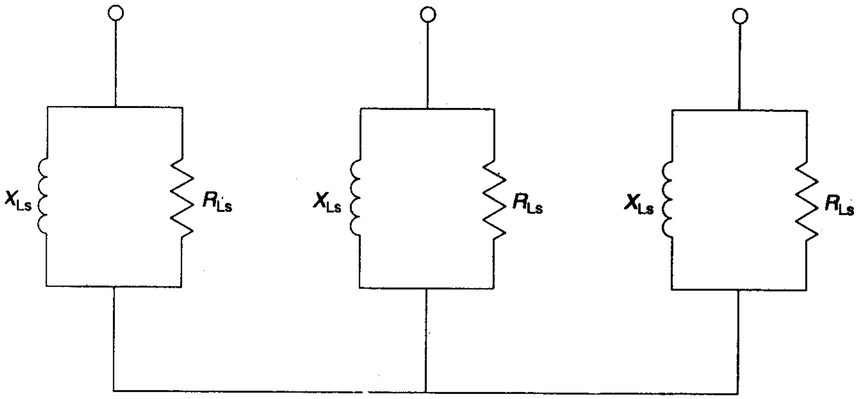
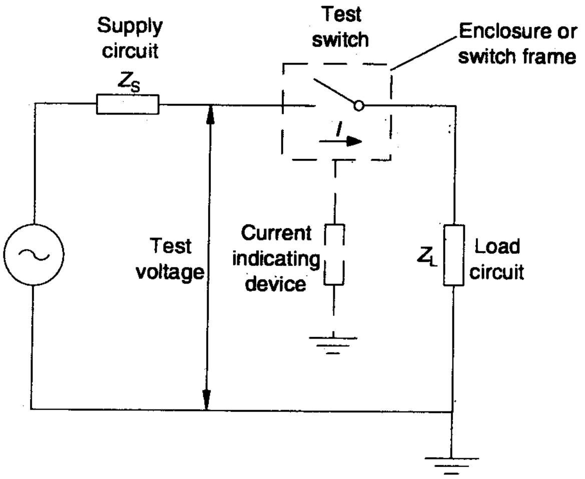


Figure 1c – Star load connection

Figure 1 – Three-phase test circuit for mainly active load current switching for test duty 1



Test voltage and current defined in table 6

Supply circuit:

power factor: ≤0,2

$Z_T = Z_S + Z_L$

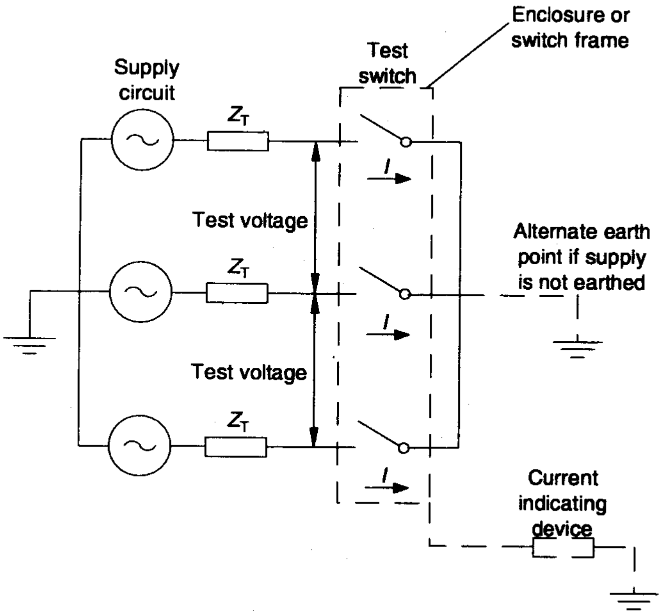
$|Z_S| = (0,15 \pm 0,03)\ |Z_T|$

TRV parameters: table 3 and 6, item 3

Load circuit:

power factor = 0,65 to 0,75

Figure 2 – Single-phase test circuit for mainly active load current switching for test duty 1


Enclosure or switch frame
Supply circuit
Test switch
Z_T
I
Test voltage
Z_T
Alternate earth point if supply is not earthed
I
Test voltage
Z_T
I
Current indicating device

$Z_T = Z_S + Z_L$ (refer to item a) of 6.101.8.2)

Test duty 2a – Line circuit:

test voltage = 0,20 U_r

test current = I_{2a}

power factor ≤0,3

TRV parameter: table 4a

Test duty 2b – Parallel-power transformer circuit:

test voltage = 0,15 U_r

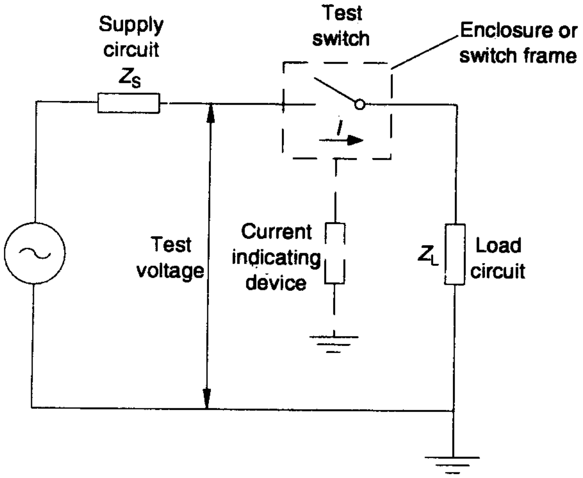
test current = I_{2b}

power factor ≤0,2

TRV parameters: table 4b

NOTE – The common switch connection may be earthed as an alternative to the supply neutral.

Figure 3 – Three-phase test circuit for distribution line closed-loop and parallel transformer current switching test for test duties 2a and 2b



$Z_T = Z_S + Z_L$ (refer to item a) of 6.101.8.2)

Test duty 2a – Line circuit:
test voltage and current defined in table 6
power factor ≤0,3
TRV parameters: table 6, item 3

Test duty 2b – Parallel-power transformer circuit:
test voltage and current defined in table 6
power factor ≤0,2
TRV parameters: table-6, item 3

Figure 4 – Single-phase test circuit for distribution line closed-loop and parallel transformer current switching test, for test duties 2a and 2b

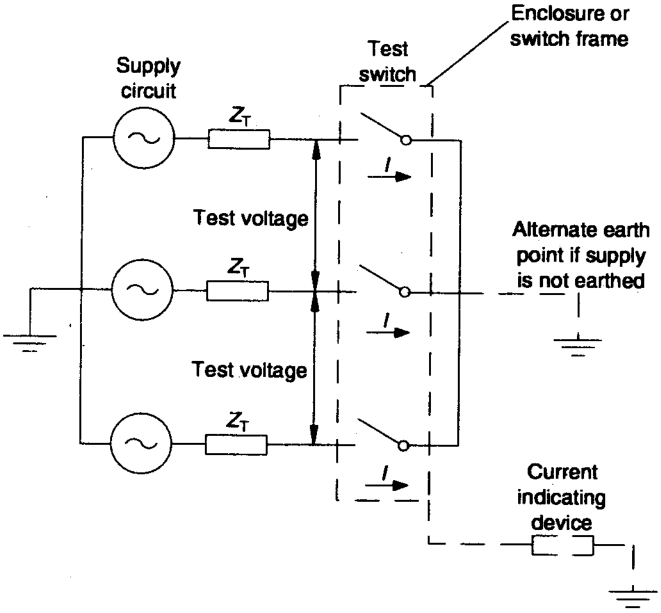

Supply circuit
Test switch
Enclosure or switch frame
Z_T
I
Test voltage
Alternate earth point if supply is not earthed
Z_T
I
Test voltage
Z_T
I
Current indicating device

Figure 5 – Three-phase test circuit for short-circuit making current test for test duty 5

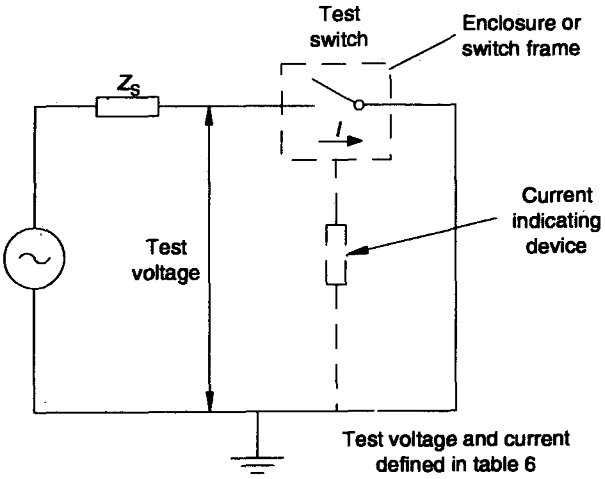
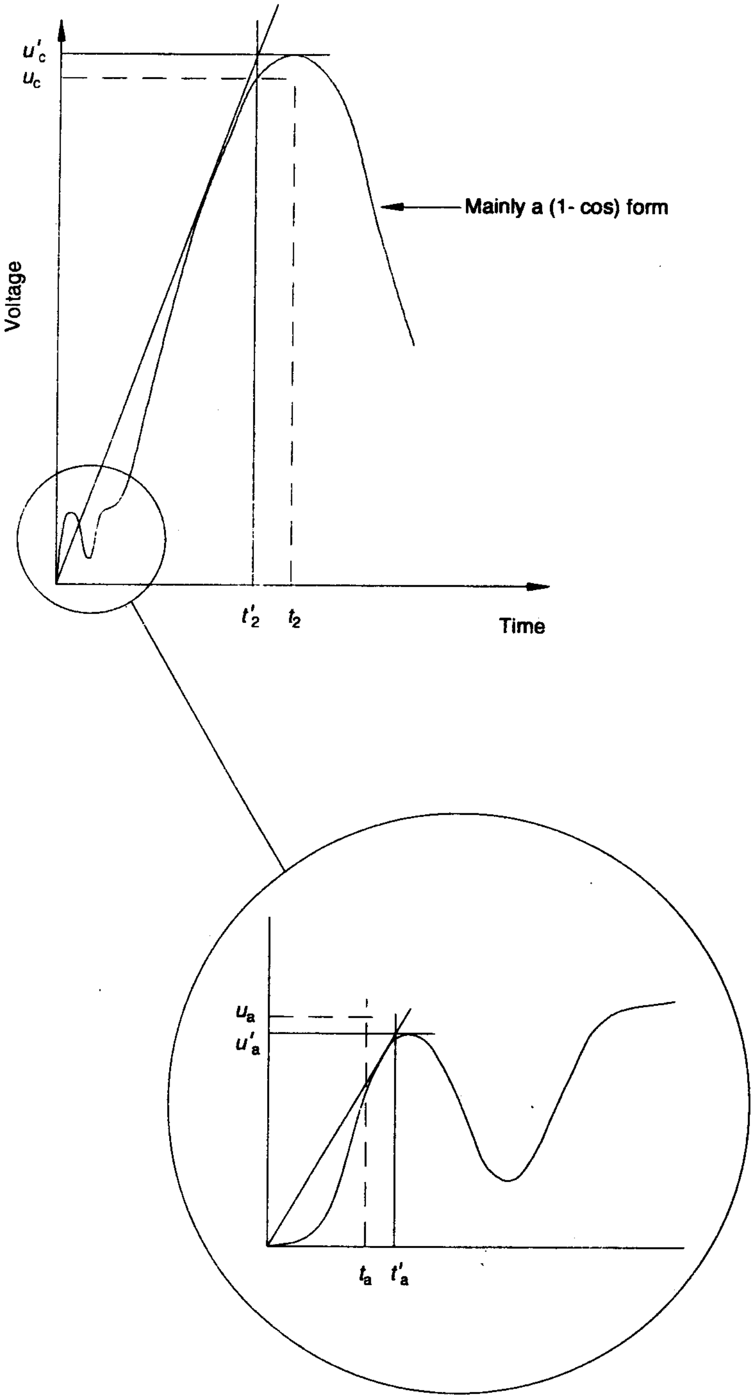


Figure 6 – Single-phase test circuit for short-circuit making current test for test duty 5



The prospective TRV (u'_a, t'_a, u'_c, t'_2) shall be as follows:

$u'_a < u_a$ $\quad$ $u'_c > u_c$

$t'_a > t_a$ $\quad$ $t'_2 < t_2$

u_a, t_a, u_c and t_2 are defined in table 9.

Figure 7 – Prospective TRV parameter limits for single-phase capacitor bank current breaking tests

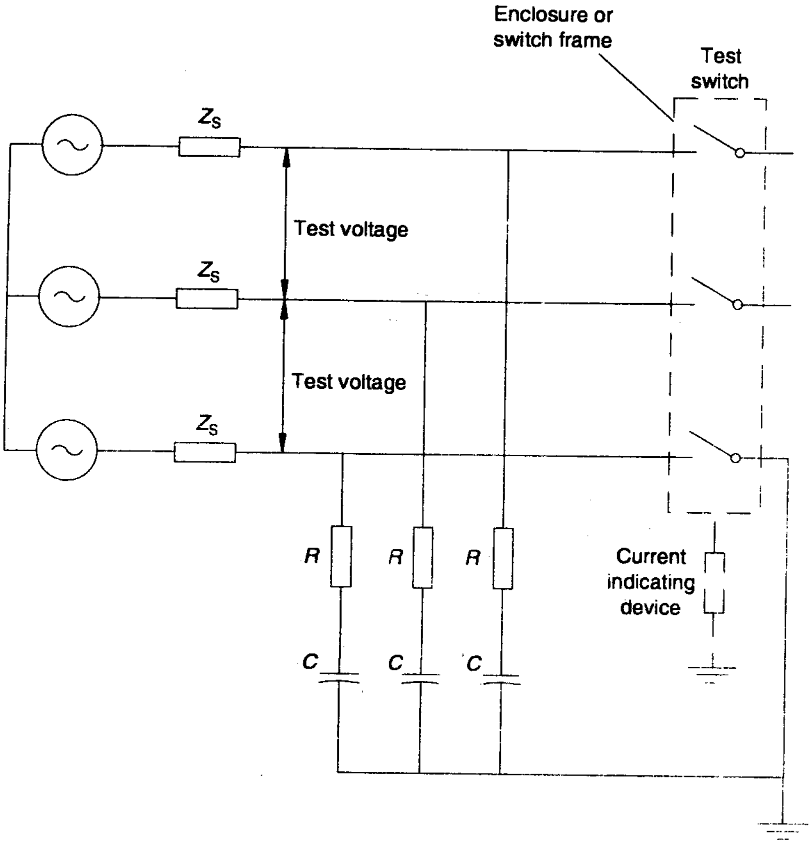


Figure 8 – Three-phase test circuit for earth fault breaking current tests, for test duty 6a

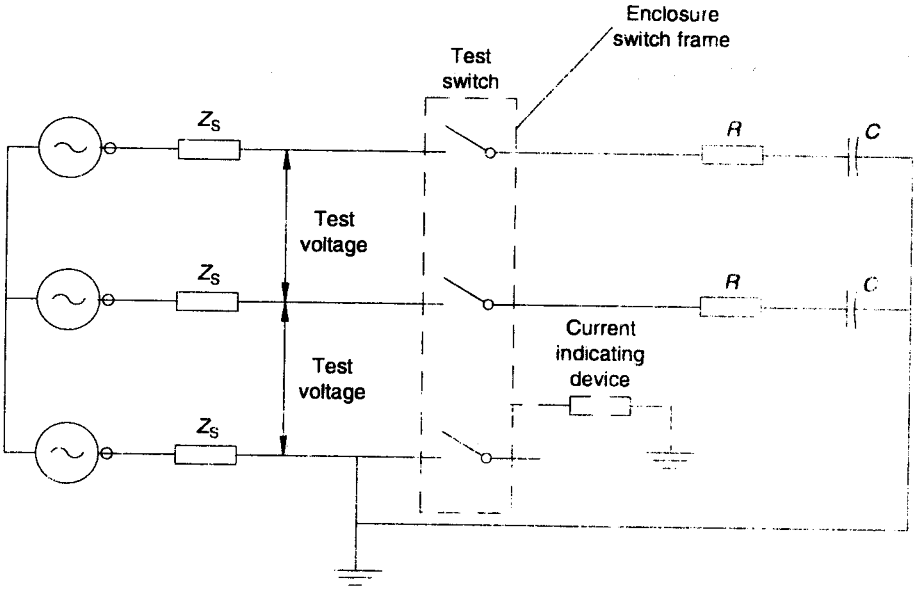


Figure 9 – Three-phase test circuit for cable-charging breaking current tests under earth fault conditions, for test duty 6b

CORRIGENDUM

Page 23

6.101.10 Short-circuit making tests for general purpose switches

Add, after the first paragraph, the following text:

The tests shall be performed with a sequence of two C operations with a no-load O in between, i.e. C – O (no-load) – C.

For class E2 switches, the test sequence is 2C – x – 1C, where x represents arbitrary switching tests, or even no-load tests.

For class E3 switches, the test sequence is 2C – x – 2C – y – 1C, where x and y represent arbitrary switching tests, or even no-load tests.

For class E2 and E3 switches, the 2C operations consist of C – O (no-load) – C.

(*Continued from second cover*)

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
	b) IS 2165 (Part 2) : 1983 Insulation coordination: Part 2 Phase to phase insulation coordination, principles and rules	Identical
IEC 60129 (1984) Alternating current disconnectors and earthing switches	a) IS 9921 (Part 1) : 1981 Alternating current disconnectors (isolators) and earthing switches for voltages above 1 000 V: Part 1 General and definitions	
	b) IS 9921 (Part 2) : 1982 Alternating current disconnectors (isolators) and earthing switches for voltages above 1 000 V: Part 2 Rating	
	c) IS 9921 (Part 3) : 1982 Alternating current disconnectors (isolators) and earthing switches for voltages above 1 000 V: Part 3 Design and construction	
	d) IS 9921 (Part 4) : 1985 Alternating current disconnectors (isolators) and earthing switches for voltages above 1 000 V : Part 4 Type tests and routine tests	
IEC 60420 (1990) High-voltage alternating current switch-fuse combinations	IS 14666 : 1999 High voltage alternating current switch fuse combinations	
IEC 60694 (1996) Common specifications for high-voltage switchgear and controlgear standards	Nil	
IEC 61233 (1994) High-voltage alternating current circuit-breakers — Inductive load switching	Nil	

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2:1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Only the English text of the International Standard has been retained while adopting it in this Indian Standard.

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Amendments Issued Since Publication

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